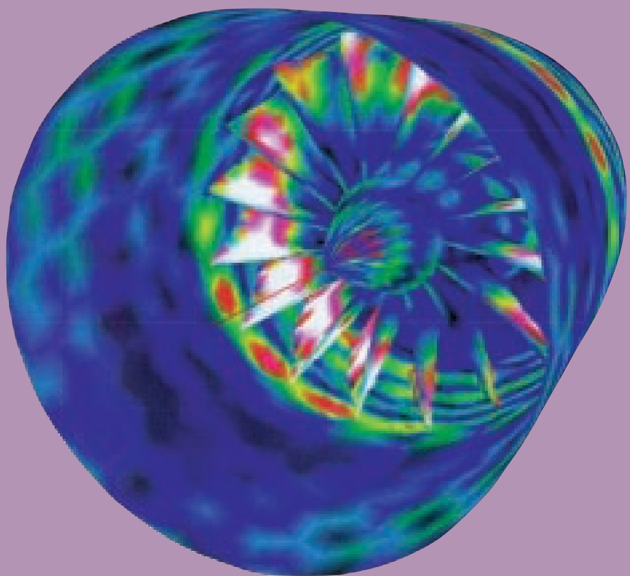
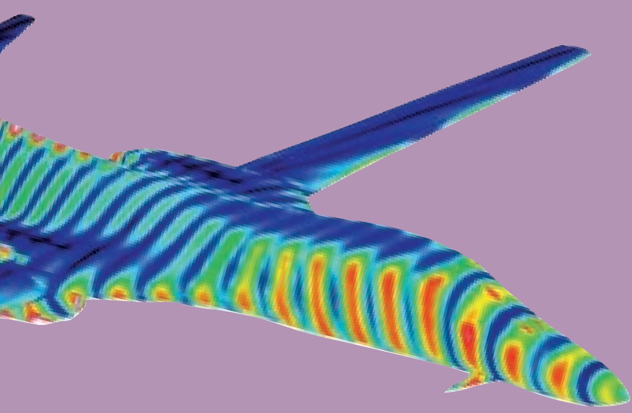
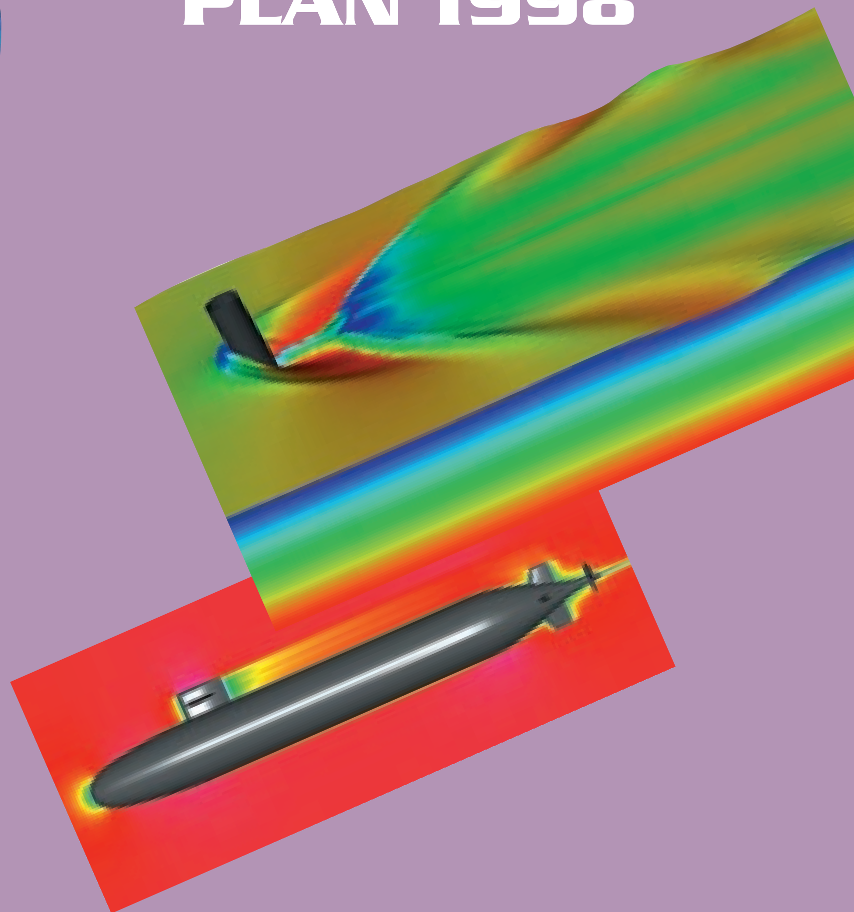
DoD HPC MODERNIZATION PROGRAM

Department of Defense High Performance Computing

MODERNIZATION PLAN 1998

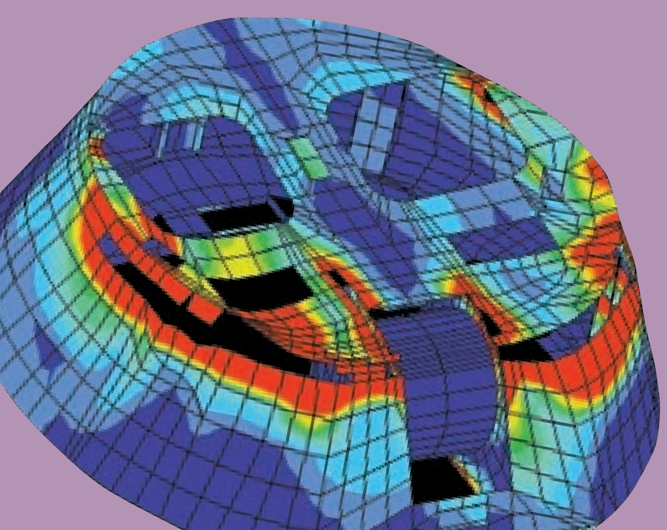






High Performance Computing

Supporting the Warfighter



Front cover captions (clockwise starting from top right):

Computed wave pattern at an instant. Free surface is color-coded with the velocity magnitude; side boundary surface is color-coded with the fluid pressure.

Axial velocity contours after 10 propulsor revolutions

M113/BMP-2 OSV turret plastic equivalent strain contour plot showing deformation after 50 ms of simulated rollover

Contours of electric field scattered from B-1B

Current image on GE404 nozzle (2 GHz, vertical polarization)

Back cover captions (clockwise starting from top right):

Mach field in stable level flight

LOCAAS geometry in stowed configuration

Simulation of solid para-hydrogen (small purple spheres) doped with atomic lithium impurities (larger orange spheres) at 4 K. The doping level is 3.3 mol percent. In the lower right, a section of the hydrogen has been cut away so that the progress of the lithium recombination can be seen more clearly.

Gridless large eddy simulation computation of the turbulent bow wave on the DDG-51

Mean sea surface height in the Gulf Stream region from the 1/32-degree Atlantic model compared with the Gulf Stream northern edge from satellite infrared imagery (1982 to 1996) mean

Mach contours showing the interference flow field between the missile and the BAT submunition at different radial locations

contents

HIGH PERFORMANCE COMPUTING MODERNIZATION PLAN

March 1998

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
3030 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3030

This is the fourth edition of the Department of Defense High Performance Computing Modernization Plan. This plan has been prepared as required by Report H.R. 105-206 that accompanied the Department of Defense Appropriation Bill, Fiscal Year 1998.

We continue to make significant progress towards our goal of improving the Department's ability to exploit computation to provide the warfighter with the technological advantage. We continued to strengthen the capability of the Department's high performance computing resources for the science and technology and the developmental test and evaluation programs.

Many of our leading edge computationally intensive projects are making critical contributions to high-priority warfighter systems; others are addressing research challenges fundamental to assuring defense technology competitiveness on the 21st century battlefield. A comprehensive presentation of project successes using high performance computing can be found in the 1998 edition of *High Performance Computing Contributions to DoD Mission Success.*

The High Performance Computing Modernization Program provides an essential enabling technology that our leading scientists and engineers are using to assure our armed forces retain technological advantage and force dominance on tomorrow's battlefield.

Sincerely,

George T. Singley, III
Acting

EXECUTIVE SUMMARY

High performance computing (HPC) has historically played a major role in the ability of the United States to develop and deploy superior weapons, warfighting capabilities, and mission support systems. Under the auspices of the Director, Defense Research and Engineering (DDR&E), the Department of Defense (DoD) High Performance Computing Modernization Program (HPCMP) is the focused modernization effort within the DoD to acquire, manage, and sustain modern HPC resources in support of defense science and technology, and developmental test and evaluation.

The HPCMP is rapidly evolving past its initial program development and procurement start-up phase and is increasing focus on application of HPC technology and resources to priority defense requirements. This plan describes some of the accomplishments achieved by the program in Fiscal Year (FY) 1997 and outlines the major strategies and milestones we expect to achieve over the next two years. The overriding goal of the program is to exploit HPC technology for military advantage across battlespace. The strategy to achieve this goal is to acquire and sustain world-class high performance computing and network capabilities for use by defense scientists and engineers.

The use of HPC technology is reducing costs and time to perform systems analysis, design, development, test, and deployment; helping avoid environmental damage; and improving the integration and effectiveness of complex weapons systems. As the DoD continues to reform and reengineer its acquisition processes, HPC assets, along with high-fidelity scalable models and simulations, are being used to reduce the number and cost of building expensive prototypes. High-fidelity modeling and simulation is also being used to explore more design options and identify important testing priorities at a fraction of the cost and time than was possible with traditional theoretical, experimental, or operational methods. As a result of these and similar mission impacts, HPC has become recognized as a key ingredient to the successful implementation of major DoD acquisition programs. The technology is considered fundamental to the success of the Simulation Based Acquisition and Simulation Based Design reform initiatives.

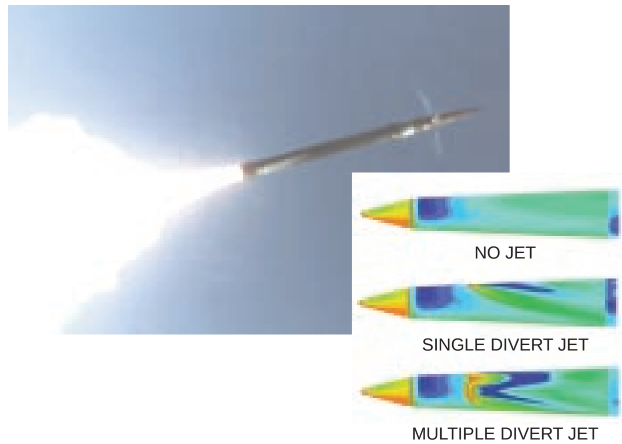
During FY 1997, the HPCMP acquired and installed the first phase of its Performance Level II capability. These actions increased threefold the peak computational capacity of the program's major shared resource centers. At the same time, several applications development teams began releasing validated alpha and beta versions of their new scalable software, further expanding the use of more powerful scalable HPC technology into day-to-day research and development efforts of the DoD. In addition, the first high-speed, high-bandwidth network connections, available under the new Defense Research and Engineering Network (DREN) contract, were implemented as previous Interim DREN sites, and new sites took advantage of enhanced network services.

Also in FY 1997, the Major Automated Information System Review Council (MAISRC), responsible for oversight of the HPCMP within the Office of the Secretary of Defense, began an aggressive testing schedule of the major initiatives of the program. Teams were sent out to test and evaluate the performance capabilities of the various HPC major shared resource centers (MSRCs), distributed centers (DCs), and application development teams.

Over the next three years, the HPCMP will complete its Performance Level III capability upgrades, more than doubling HPC capability within the DoD. At the same time, demand for these resources is expected to rise at an even greater rate, necessitating continued close management and prioritization of HPC assets across the many users of these systems.

The success of the DoD HPCMP is ultimately measured by what HPC resources enable defense scientists and engineers to accomplish for the warfighter. While the full impact of inserting HPC technology into the defense acquisition process will not be clearly visible until resulting weapons, capabilities, and support systems have been deployed and battle tested, an estimate of the value of these systems is beginning to take shape. Major success stories, technical papers, and scientific breakthroughs are being released regularly; use of this technology by over 4,000 defense scientists and engineers has more than tripled in the past two years. A small sampling of notable successes using HPC technology can be seen on the next two pages. A more in-depth review of these efforts and other major HPC successes can be found in the 1998 edition of *High Performance Computing Contributions to DoD Mission Success.*

♦ Aerodynamic Control of Theater Defense Missiles Using Jet Interaction

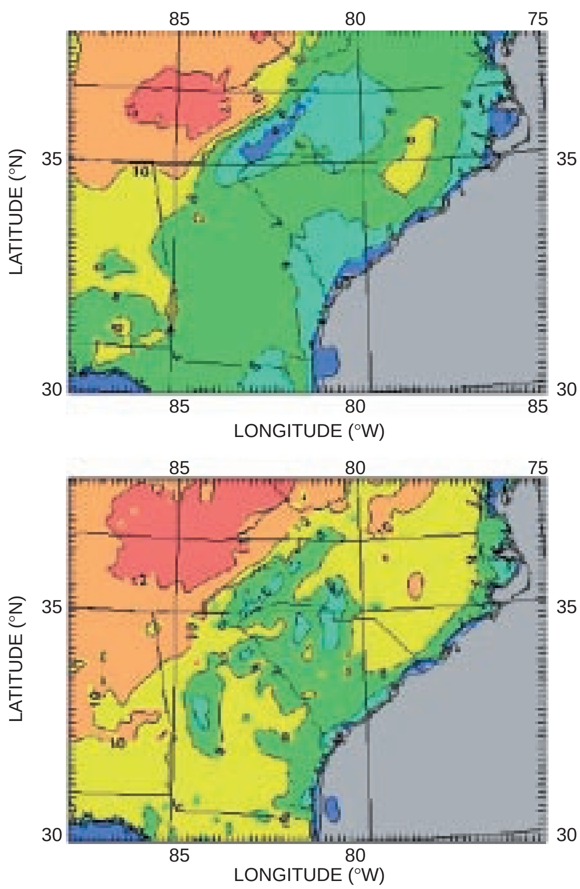


Problem: Enemy theater ballistic missiles and cruise missiles have emerged as a serious threat to both ground forces and civilian populations. Our ability to track, acquire, and destroy these threats depends on our ability to operate across a wide range of altitude and atmospheric conditions that cannot always support the necessary maneuvering agility using traditional aerodynamic control surfaces such as fins or strakes. Wind tunnel experiments are insufficient to resolve the complex interactions and control performance of the missile under various conditions.

Approach: Use advanced numerical algorithms coupled with high performance computational resources to attack the three-dimensional problem of effective jet interaction control and autopilot design.

Results: Defense researchers have resolved several critical issues of jet interaction control and generated the extensive single and multiple jet data needed to understand different aspects of jet interaction control during flight. These findings are now being used to improve guidance and control accuracy, maneuverability, and reliability of the interceptors needed to destroy enemy targets across multiple engagement conditions. With HPC resources, an efficient and robust autopilot can be designed and tested for use across the entire battlespace.

♦ Spatial Distribution of Water Vapor Using Visible-Band Geostationary Satellite

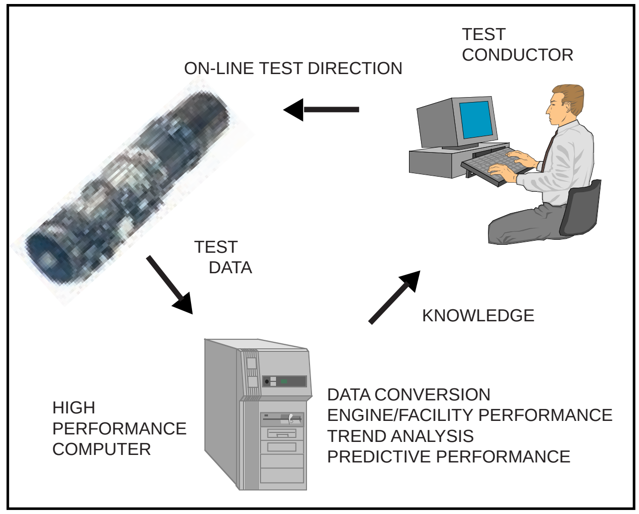


Problem: Turbulent convection, water vapor, and cloud formations can affect theater operations dramatically, creating poor line-of-sight visibility, increasing threats to pilot safety, and decreasing weapon system performance and communications.

Approach: Improve weather prediction models by increasing their ability to accurately simulate and predict horizontal variations in surface heating and precipitation. Model predictions can also be improved greatly by feeding them real-time, visible-band satellite imagery that precisely identifies positions and movements of clouds and water vapor observations.

Results: Using HPC technology, new higher fidelity weather models, integrated with real-time satellite data, are producing more accurate predictions of shelter height temperatures, moisture convergence patterns, and surface winds. These positive effects are maintained throughout a 9-hour forecast, providing better predictions of clouds, precipitation, and associated aviation and weapon system impact variables (e.g., icing, downbursts). This technology is also being transferred to the civilian aviation community and other applications interested in the effects of weather.

♦ On-Line Turbine Engine Test Support

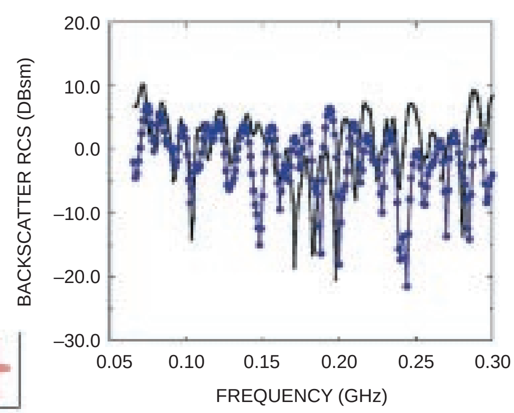


Problem: Air-on-hours for turbine engine testing are very expensive ($10,000/hour for small tests and up to $27,000/hour for larger tests). Testing of modern turbine engines also requires hundreds or thousands of sensors collecting a wide variety of performance data simultaneously, several thousand times a second. Processing test data on-line is required to make critical decisions during the test, prevent expensive future retesting, and support timely acquisition decisions.

Approach: Leading-edge high performance computing resources are incorporated with array processors in the data acquisition stream to convert raw test data to engineering units (EU) data. EU data are sent to an HPC system for real-time and near-real-time calculation of engine performance parameters. Performance data are then sent over a high-speed communications network to local workstations for on-line analysis and to a central archive for future access.

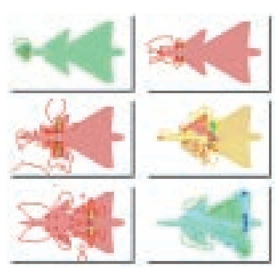
Results: With modern HPC technology, test data point turnaround time was decreased from an average of 10 minutes to 2 minutes. This concept was originally targeted for the F119 engine development tests, but because of its successful cost reduction and improved turnaround time, it has been expanded to several turbine engine tests such as the F100, F110, F414, F402, F404, Pratt & Whitney 4000, and Rolls Royce Trent engine.

♦ Broadband Electromagnetic Simulation on Unstructured Grids



Problem: Electronic warfare requirements across many of our critical defense systems call for rapid computing of broadband radar scatter, advanced radar range design and simulation, and determination of the effects of high-power microwaves, electromagnetic interference (EMI), and electromagnetic pulse (EMP).

Approach: HPC technology is being used to generate and analyze high-fidelity grids for complex targets such as fighter aircraft and fit them to target surfaces from a standard CAD database. Accurate propagation of waves over the target through variable geometry of unstructured cells is a major challenge requiring very large computational capabilities.



Results: Computational electromagnetics (CEM) has rapidly become integral to advanced aerospace design, not only as a stand-alone technology, but also as part of a multidisciplinary coupling that leads to well-optimized designs. HPC technology has advanced our knowledge and simulation of radar cross sections (RCS) for several very difficult targets. The first pulse calculation of backscatter RCS for a fighter aircraft using an HPC-based unstructured grid CEM code is shown above for a nose-on incidence. The figures illustrate the passage of a vertically polarized plane pulse over the target, showing the total horizontal electric field at each instant. This information is being used to assess the vulnerability of friendly and enemy warfighting platforms across a wide variety of electromagnetic frequencies. It also allows defense scientists and engineers to design more effective electronic countermeasures to protect our warfighting platforms and develop more effective weapons to exploit vulnerabilities in target platforms.

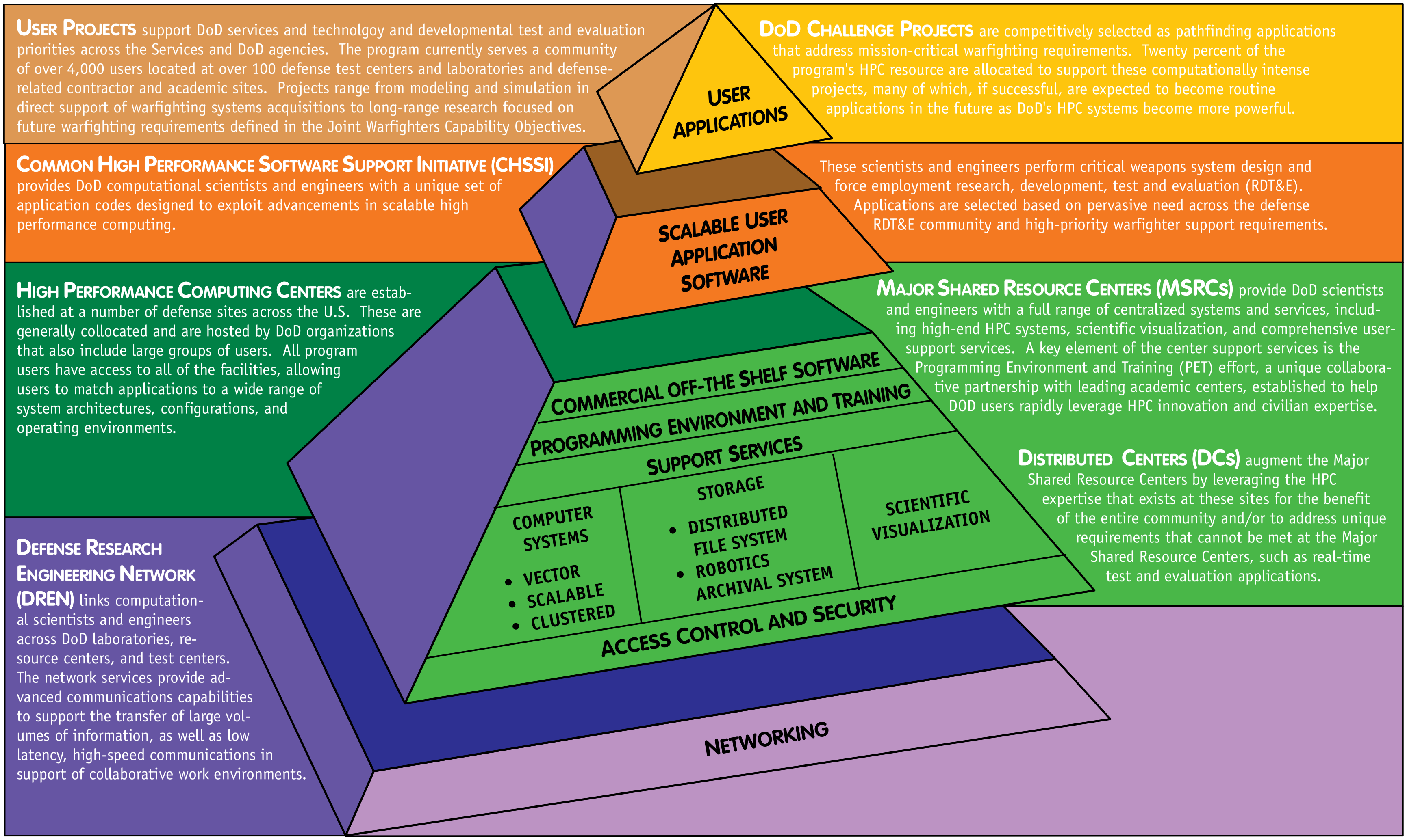


Figure 1 – DoD HPC Modernization Program integrated program strategy

PROGRAM OVERVIEW

History

The High Performance Computing Modernization Program (HPCMP) was initiated in FY 1993 in response to congressional direction to modernize the Department of Defense (DoD) HPC capabilities. Early on, senior leaders recognized the unique potential of this emerging technology as critical to our nation's future defense. The High Performance Computing Modernization Office (HPCMO), staffed with representatives from each Service, was established in FY 1994 to perform life cycle management and acquisition oversight needed to ensure that the program supports the HPC needs of the defense science and technology (S&T) and developmental test and evaluation (DT&E) communities. The program has evolved past an initial start-up phase of procurement and program development activities. Since FY 1996, it has fielded a world-class HPC infrastructure, available to the full S&T and DT&E communities, that includes 4 major shared resource centers and 13 smaller focused distributed centers across the country. Figure 1 illustrates the DoD HPCMP integrated program strategy.

Program Mission

> *The HPCMP mission is to modernize the high-end high performance computing capability used by the DoD science and technology and developmental test and evaluation communities, in order to incorporate technological advantage into superior weapons, warfighting capabilities, and related support systems and to accomplish this advantage more rapidly and affordably with reduced risks to human life and optimized system performance.*

Program Vision

> *The HPCMP vision is to enable the DoD to maintain its technological supremacy over adversaries of the United States in weapon systems design and to foster the flow of this technology into warfighting support systems by providing world-class HPC capability to the science and technology and developmental test and evaluation communities.*

Program Scope

The HPCMP scope is bounded both in terms of the user community it serves and the technological capability it delivers. By limiting the scope and by concentrating the majority of resources at a small number of shared centers, the program has been able to provide world-class computing capabilities that could not have efficiently been obtained and sustained by individual Services or Agencies. This sharing of resources reduces overall acquisition and sustainment costs and fosters collaboration and cooperation across the DoD S&T and DT&E communities.

The scope of the user community is defined by Congress (Public Law 104-61, December 1, 1995, 109 Statute 665, Sec. 8073) to be

> *"….. (1) the DoD Science and Technology (S&T) sites under the cognizance of the Director, Defense Research and Engineering, (2) the DoD Test and Evaluation (DT&E) centers under the Director, Test and Evaluation (Office of the Under Secretary of Defense, Acquisition and Technology), and (3) the Ballistic Missile Defense Organization . ."*

While the program serves the DT&E community, it is important to note that its scope does not address operational test and evaluation requirements — including live fire testing. Nor is it funded sufficiently to address many of the unique applications that are not easily handled at multiuser shared centers such as those maintained by this program. Recognizing these limitations, and in response to congressional reporting requirements,* the Director, Developmental Test, Systems Engineering and Evaluation, and the Director, Operational Test and Evaluation, are currently developing a separate plan for integrating HPC fully into the production test and evaluation process and enterprise.

From a technology capability perspective, the program maintains a strict focus on providing high performance computing. The definition of "high performance computing" changes as the technology continues to evolve. This consistent evolution requires that the program continually

---

**National Defense Authorization Act for Fiscal Year 1996*, Conference Report 104-450, pp 701-702.

reassess its acquisition plans to ensure that it is not acquiring systems that have become "departmental" class — computational capability that remains the responsibility of the local mission organization. The rapid evolution of high performance computing also requires that the program focus on delivering improved capability early in its commercial life cycle. This allows the DoD to maintain the technological edge required to analyze, design, produce, and deploy advanced weapons systems and capabilities to the warfighter — before similar computational capabilities are available to our adversaries and economic competitors.

Program User Requirements

From its inception, the HPCMP was designed to address the continuing high-end computing needs of the DoD S&T program. Congress later amended the program scope to its current user base of over of 4,000 scientists and engineers located at more than 100 DoD laboratories, test centers, and contractor and academic sites. Each member of this community continues to have evolving requirements for high-end HPC technology. These requirements are identified and tracked via an extensive annual effort led by the program office and a working group of representatives of all of the major components of the user community.

The requirements process developed and used by the program includes a series of surveys sent to users and potential users throughout the DoD S&T and DT&E communities, coupled with visits to selected sites to discuss requirements. In addition, the program obtains feedback through user satisfaction surveys, annual user group meetings, and advisory panels that work with resource managers to establish policies and procedures at the shared resource centers.

A vigorous requirements gathering and validation process was initiated in FY 1994 to establish a baseline of existing HPC resources and determine the present and future needs for such resources. This on-going process includes an annual analysis and revalidation of short-term and longer term user needs to provide accurate, timely data on which to base program decisions.

Figure 2 shows the HPC capabilities needed to resolve important problems in six computational technology areas (CTAs) with varying degrees of fidelity. Increasing fidelity is required to solve critical problems such as model-driven Integrated Modeling and Test Environments (IMT) and high-fidelity Forces Modeling and Simulation (FMS). Other important HPC-related resource requirements, such as on-line file storage, archival data, and network bandwidth are not reflected in Figure 2. However, these needs also require significant increases in capability to resolve important defense problems across the CTAs.

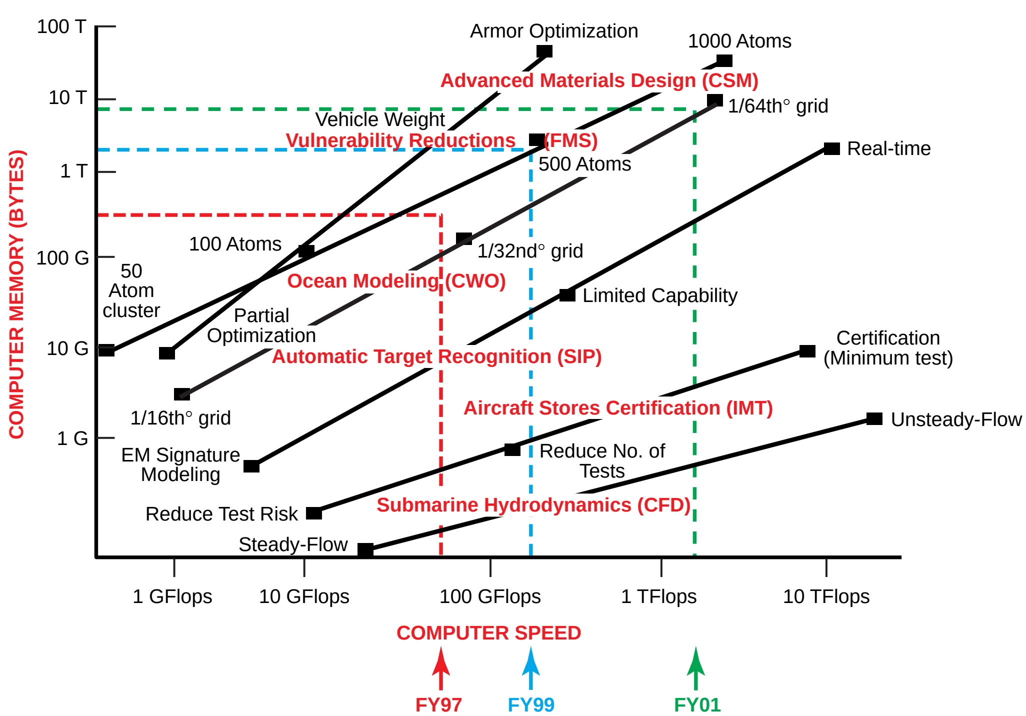


Figure 2 – HPC resource requirements for important computational technology area problems

Computational Technology Areas

The DoD HPCMP user community is organized around 10 CTAs. Each CTA has a designated leader who is a prominent DoD scientist or engineer working within the research disciplines included in his CTA. Table 1 provides a brief description of each CTA, and Table 2 lists the CTA leaders. CTA leaders serve for a term of approximately three years, and, beginning in FY 1998, will be rotated among the military Services.

Table 1 — Computational Technology Areas

Computational Structural Mechanics CSM provides high-resolution, multidimensional modeling of materials and structures subjected to a broad range of static, dynamic, and impulsive loading conditions. Uses include effects of explosions on various facilities, underwater explosion and ship response, structural acoustics, structural analysis, propulsion systems, lethality and survivability (aircraft, ships, submarines, tanks), theater missile defense, and real-time, large-scale soldier and hardware-in-the-loop vehicle dynamics.	**Signal/Image Processing** SIP provides for extraction and analysis of key information from various sensor outputs in real time. Sensors include sonor, radar, visible and infrared imagers, and signal intelligence and navigation assets. Uses include intelligence, surveillance and reconnaissance (ISR), avionics, communications, smart munitions, and electronic warfare. Functions include detecting, tracking, classifying, and recognizing targets in the midst of noise and jamming; generating high-resolution low-noise imagery; and the compression of imagery for communications and storage.
Computational Fluid Dynamics CFD provides the accurate numerical solution of the equations describing fluid and gas motion and fluid-dynamics research. Uses include the design of complex combustion and propulsion systems that are inaccessible or too costly to prototype; the dynamics of submarines, subsonic, transonic and supersonic air vehicles, pipe flows, air circulation, missiles, projectiles; and magnetohydrodynamics for advanced power systems and weapons effects.	**Forces Modeling and Simulation/C4I** FMS integrates high-speed command, control, communications, computers, and intelligence (C4I) systems to manage a battle space; provides large-scale simulations of complex military engagements to facilitate mission rehearsal/training, mission planning, and postmission analysis; and advances digital library technology for support of FMS/C4I research and development activities. Uses span the design, development, test, evaluation, and deployment of a variety of warfighting and training systems.
Computational Chemistry and Materials Science CCM provides prediction of basic properties of new chemical species and application of this molecular understanding to the development of advanced materials. Uses include design of new chemical compounds for fuels, lubricants, explosives, rocket propellants, and chemical defense agents. In addition, advanced modeling techniques are used to develop new high performance materials for electronics, advanced sensors, aircraft engines, semiconductor lasers, laser protection systems, advanced rocket engines components, and biomedical applications.	**Environmental Quality Modeling and Simulation** EQM provides high-resolution three-dimensional Navier-Stokes modeling of hydrodynamics and contaminant transport through air, ground, and aquatic ecosystems. Uses include stewardship and conservation of natural and cultural resources; prediction of chemical, and biochemical contaminant flows; design and operation of installation restoration; integrated management in support of environmental quality; noise evaluation and abatement; and water quality models.
Computational Electromagnetics and Acoustics CEA provides high-resolution multidimensional solutions of Maxwell's equations and acoustic wave equations. Uses include calculating fields about antenna arrays; signatures of tactical ground, air, sea, and space vehicles; the signature of buried munitions; performance/design factors for electromagnetic gun technology; high-power microwave performance; modeling of acoustic fields for surveillance and communication; seismic fields for mine detection; and acoustic shock waves of explosions for antipersonnel weapons.	**Computational Electronics and Nanoelectronics** CEN provides the design, modeling, and simulation of complex electronic devices, integrated circuits, and small components. Uses include lower costs, weights, size, and improved performance of electronics through predictive high-fidelity modeling and simulation; analog/digital high-frequency circuit and device simulation and optimization; modeling and simulation of micro-electromechanical devices, micro-resonators, active and passive millimeter-wave circuits and structures; electronic/photonic interconnect and packaging analysis; and fault modeling.
Climate/Weather/Ocean Modeling and Simulation CWO provides the numerical simulation and forecast of the Earth's climate as well as oceanic and atmospheric variability. Uses include improved flight safety; search-and-rescue mission planning; propagation of weapons; aircraft and ship routing; antisubmarine and undersea warfare; enhanced capabilities in adverse weather; and the capability to predict magnetic storm-induced effects and outages on command, control, communications (C^3), surveillance, and navigation systems.	**Integrated Modeling and Test Environments** IMT applies high performance computing software tools and techniques with live tests and hardware-in-the-loop simulations for test and evaluation of DoD weapons, components, subsystems, and systems in virtual and composite virtual/real environments. Uses include digital scene generation, six degrees-of-freedom trajectory simulations, real-time test-data analysis and display systems for test control and evaluation, and high-fidelity engineering and closed-loop engagement models (one-on-one and few-on-few).

Table 2 — Computational Technology Areas Leaders

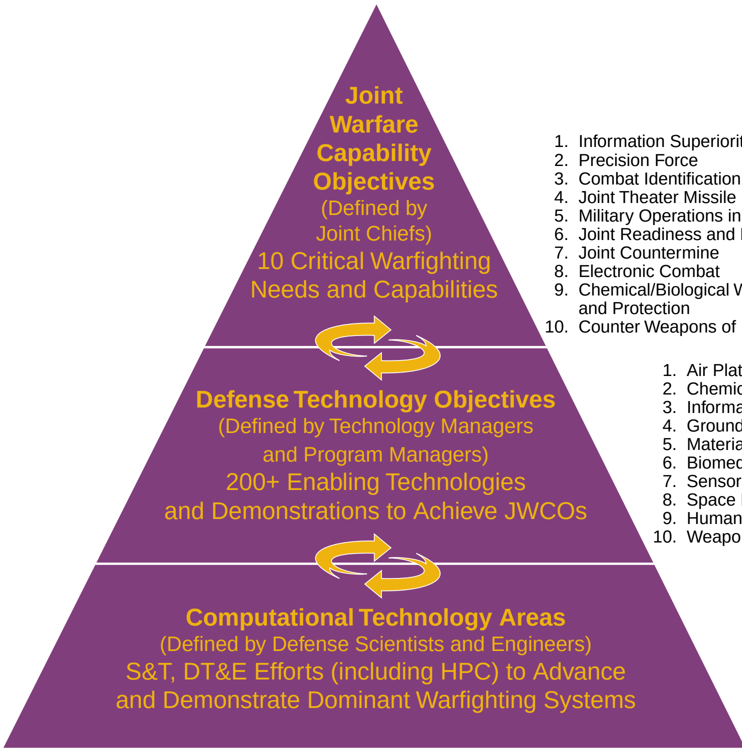
Computational Technology Area	Area Leader	Location
Computational Structural Mechanics	Kent Kimsey	Army Research Laboratory (Aberdeen)
Computational Fluid Dynamics	Jay Boris	Naval Research Laboratory (DC)
Computational Chemistry and Materials Science	Scott Wierschke	Air Force Research Laboratory (Edwards)
Computational Electromagnetics and Acoustics	Joseph Shang	Air Force Research Laboratory (Wright)
Climate/Weather/Ocean Modeling and Simulation	Joseph McCaffrey	Naval Research Laboratory (Stennis)
Signal/Image Processing	Richard Linderman	Air Force Research Laboratory (Rome)
Forces Modeling and Simulation/C4I	Robert Wasilausky	Naval Space and Warfare Systems Center, San Diego
Environmental Quality Modeling and Simulation	Jeffery Holland	Army Waterways Experiment Station
Computational Electronics and Nanoelectronics	Barry Perlman	Army Research Laboratory (Fort Monmouth)
Integrated Modeling and Test Environments	Andrew Mark	Army Research Laboratory (Aberdeen)

Teams of leading defense scientists and engineers use HPC resources to develop, advance, and maintain hundreds of scientific algorithms, codes, models, and simulations needed to analyze, design, develop, test, evaluate, and deploy technologically superior weapons, warfighting capabilities, and related support systems. Their efforts produce and support key enabling technologies, capabilities, and demonstrations articulated by the various Defense Technology Objectives (DTOs). These enabling DTOs, in turn, support the 10 most critical Joint Warfighting Capability Objectives (JWCOs) promulgated by the Joint Requirements Oversight Council (JROC) of the Joint Chiefs of Staff.*

While not all-inclusive, JWCOs provide focus, priority, and a common reference point for much of the DoD's research, development, test, and evaluation efforts. They are described in detail in the annual *Joint Warfighting Science and Technology Plan* published by the Director, Defense Research and Engineering and include (1) information superiority, (2) precision force, (3) combat identification, (4) joint theater missile defense, (5) military operations in urban terrain, (6) joint readiness and logistics, (7) joint countermine, (8) electronic combat, (9) chemical/ biological warfare defense and protection, and (10) counter weapons of mass destruction.

Figure 3 shows the interrelationships between JWCOs, DTOs, and CTAs and provides just one example of how work being performed with DoD HPC resources is supporting high-priority warfighting capabilities. In most cases, each CTA supports multiple DTOs and JWCOs. Likewise, individual DTOs and JWCOs are supported by multiple CTAs.

*A detailed description of the current Defense Technology Objectives and Joint Warfighting Capability Objectives can be found in various publications updated and distributed annually by the Director, Defense Research and Engineering, including the *Defense Technology Area Plan* and the *Joint Warfighting Science and Technology Plan*. These documents can also be found on the World Wide Web at http://www.dtic.mil/ddre.



1. Information Superiority
2. Precision Force
3. Combat Identification
4. Joint Theater Missile Defense
5. Military Operations in Urban Terrain
6. Joint Readiness and Logistics
7. Joint Countermine
8. Electronic Combat
9. Chemical/Biological Warfare Defense and Protection
10. Counter Weapons of Mass Destruction

1. Air Platforms
2. Chemical/Biological Defense and Nuclear
3. Information Systems Technology
4. Ground and Sea Vehicles
5. Materials and Processes
6. Biomedical
7. Sensors, Electronics, and Battle Environments
8. Space Platforms
9. Human Systems
10. Weapons

1. Computational Structural Mechanics
2. Computational Fluid Dynamics
3. Computational Chemistry and Materials
4. Computational Electromagnetics and Acoustics
5. Climate, Weather, and Ocean Modeling
6. Signal-Image Processing
7. Forces Modeling and Simulation
8. Environmental Quality Modeling and Simulation
9. Computational Electronics and Nanoelectronics
10. Integrated Modeling and Test Environments

EXAMPLE OF HPC SUPPORT OF WARFIGHTING NEED: (COMANCHE)

Capability Need (JWCO) - Precision Force

"the capability to destroy selected high-value and time-critical targets or to inflict damage with precision while limiting collateral damage."

1. Information Superiority
2. **Precision Force**
3. Combat Identification
4. Joint Theater Missile Defense
5. Military Operations in Urban Terrain
6. Joint Readiness and Logistics
7. Joint Countermine
8. Electronic Combat
9. Chemical/Biological Warfare Defense and Protection
10. Counter Weapons of Mass Destruction

Enabling Technologies (DTO) - Air Platforms

includes: Aircraft Support/Sustainment Reduction - "develop, demonstrate, and transition technologies to extend the lives or reduce the cost of aging aircraft. The ability to predict effects of unsteady aerodynamics loads will be developed and used with advanced structural concepts to increase fatigue life and reduce the support cost of aircraft."

1. **Air Platforms**
2. Chemical/Biological Defense and Nuclear
3. Information Systems Technology
4. Ground and Sea Vehicles
5. Materials and Processes
6. Biomedical
7. Sensors, Electronics, and Battle Environments
8. Space Platforms
9. Human Systems
10. Weapons

Computational Technology Area (CTA) - Computational Fluid Dynamics

includes: Comanche Helicopter and Missile Launch - HPC used to model and simulate interactions and effects of unsteady aerodynamic conditions and missile launch on the Comanche Helicopter and its various systems. Predict loading, handling, and host vehicle damage caused by missile launch and off-body aerodynamics to support maintenance, future design modification decisions, and warfighting tactics. "

1. Computational Structural Mechanics
2. **Computational Fluid Dynamics**
3. Computational Chemistry and Materials
4. Computational Electromagnetics and Acoustics
5. Climate, Weather, and Ocean Modeling
6. Signal-Image Processing
7. Forces Modeling and Simulation
8. Environmental Quality Modeling and Simulation
9. Computational Electronics and Nanoelectronics
10. Integrated Modeling and Test Environments

Figure 3 – HPC support to JWCOs

The CTAs provide an effective framework for coordinating and focusing computation-based research efforts to analyze, research, develop, and deploy advanced weapons, warfighting capabilities, and related support systems in support of the critical DTOs and JWCOs. To maximize the ability of the DoD S&T and DT&E community to meet these mission needs, the program is providing and sustaining an increasingly powerful high-end HPC capability based on growing customer requirements. This HPC environment must be broadly accessible to all members of the community and includes

- a variety of well-balanced, high-end HPC computers;
- a full complement of systems and applications software selected to support the needs of the scientists and engineers in each of the CTAs;
- an aggressive technology insertion program that continues the education, training, and expansion of the DoD HPC community to accelerate the exploitation of HPC technology;
- a reliable high-speed network that links DoD scientists and engineers at their user sites with each other and the computational resources located at the program's shared resource centers; and
- software tools that help transition much of the highest priority DoD computational workload to scalable HPC systems.

Program Goals

The program goals established to provide an increasingly powerful high-end HPC environment to the S&T and DT&E community are to

(1) continually acquire the best commercially available high-end HPC computers,
(2) acquire and develop common-use software tools and programming environments,
(3) expand and train the DoD HPC user base,
(4) link users and computer sites via high-speed networks (facilitating the creation of collaborative work environments), and
(5) exploit the best ideas, algorithms, and software tools emerging from the national HPC infrastructure.

Program Strategies

The program strategies to achieve these goals are

(1) Goal — Continually acquire the best commercially available high-end HPC computers.

- Provide a balanced set of commercially available heterogeneous computing platforms and HPC systems to meet the full range of DoD requirements and permit optimum mapping of requirements to system types.
- Build complete HPC environments, including large computing systems, software, and support expertise at a few DoD laboratories and DT&E centers designated as major shared resource centers (MSRCs) to support a wide community of HPC users.
- Place modest-sized high performance computational systems at selected, distributed centers (DCs) when that placement allows for either innovation or mission support not provided by an MSRC.
- Support efforts to build complementary HPC capabilities and technologies throughout government, academia, and industry that are applicable to defense S&T and DT&E requirements.
- Continually acquire and upgrade equipment and support services to assure that DoD HPC centers provide world-class, state-of-the-art capabilities.

(2) Goal — Acquire and develop common-use software tools and programming environments.

- Promote standards for DoD research, development, test, and evaluation software to ensure that future transitions and advancements in software technology are applied in an efficient and cost-effective manner.
- Focus on applications software initiatives designed to overcome the technological inhibitors that may delay the effective use of scalable high performance computers.
- Support software components used in specific CTAs or by a subset of HPC users across the community.
- Identify software suites to be shared across selected MSRCs and focused DCs.

(3) Goal — Expand and train the DoD HPC user base.

- Provide user education in scalable computer and computational sciences, software applications and optimization, and code conversion.
- Promote the formation of DoD-sponsored interdisciplinary teams and collaboration groups to determine how best to support each CTA and to leverage academia and industry expertise in HPC for the solution of DoD problems.
- Develop shared application software in support of high-priority and broadly needed CTAs.
- Aggressively transfer expertise and knowledge among the DoD HPC user community.
- Expand the knowledge of the DoD HPC user community as applications require.

(4) Goal — Link users and computer sites via high-speed networks (facilitating the creation of collaborative work environments).

- Deploy robust and cost-effective network connectivity consistent with HPC traffic requirements among and between DoD scientists and engineers and HPC assets, and between the DoD and external research and test and evaluation communities.
- Encourage remote usage where appropriate.
- Ensure that the highest priority applications and end users are well supported.

(5) Goal — Exploit the best ideas, algorithms, and software tools emerging from the national HPC infrastructure.

- Ensure that DoD S&T and DT&E users remain cognizant of, interact with, and leverage internal DoD HPC initiatives, such as the Defense Advanced Research Projects Agency's technology development efforts and the software development initiatives of defense research offices (Air Force Office of Scientific Research, Army Research Office, and Office of Naval Research).
- Ensure that DoD S&T and DT&E users remain cognizant of, collaborate with, and leverage other government, academia, industry, and each other's HPC efforts.
- Maintain cooperative contact with the appropriate committees, subcommittees, working groups, and advisory panels associated with the National Science and Technology Committee (NSTC) structure.
- Maintain cooperative contact with the Department of Energy Accelerated Strategic Computing Initiative (ASCI).
- Provide HPC resources to support defense applications that directly relate to dual-use technologies and National Challenges, e.g., environment, medical, digital libraries, and manufacturing processes and products.
- Ensure the availability of HPC resources to support defense applications that address DoD Challenge Projects' needs, e.g., new materials; meteorological, oceanographic, and environmental modeling; energy efficient vehicles and airplanes; and the structure of biological and chemical phenomena.
- Leverage the nation's HPC infrastructure to benefit the warfighter.

Program Initiatives

The HPCMP pursues three initiatives to implement the program strategies outlined above and achieve its goals. Work began on each initiative in FY 1994. Initial assessments were provided in FY 1994 and were expanded in FY 1996 and each year thereafter. Implementation of program initiatives will continue as long as the DoD needs to continue broadening and improving the ability of its S&T and DT&E community to analyze, develop, and deploy advanced weapons, warfighting capabilities, and related support systems more rapidly and affordably and with reduced risks to human life and system performance.

Goals	Program Initiative
1,2,3,5	HPC centers
3,4,5	networking
2,3,5	software support

HIGH PERFORMANCE COMPUTING CENTERS

Major Shared Resource Centers (MSRCs)

To enable the DoD S&T and DT&E community to effectively and efficiently use a full range of high-end HPC resources, the HPCMP has established four large MSRCs. Sustainment of resources at the MSRCs, along with the needed support staff, are provided by a team of government and contractor personnel. Table 3 lists the four MSRCs.

Each MSRC includes various types of high-end high performance computing and communications systems, scientific visualization capabilities, peripheral and archival storage devices, and support staff providing expertise in the use of these assets, with an emphasis on supporting large computational requirements/problems. Further, each center's hardware configurations, software, programming environments, and training efforts are focused to best support the needs of a particular set of CTAs designated for that center. Table 4 shows which MSRCs are tasked to provide emphasis support to which CTAs.

A key element of support at each MSRC is the Programming Environment and Training (PET) effort. This effort, in addition to extensive training to meet a wide variety of user needs, also provides system tools and knowledge about state-of-the-art HPC technology to facilitate the effective and efficient use of the various HPC systems. This support is accomplished through collaborative partnerships established by each MSRC with several leading civilian HPC centers and academic institutions in order to rapidly capture innovation and draw needed civilian expertise into the DoD. Organized to provide emphasis on particular CTAs, MSRCs focus on training the DoD user base, identifying HPC technology opportunities, and introducing these opportunities into the shared resource centers' computing environment.

Table 3 — Major Shared Resource Centers

Center	Location
Air Force Aeronautical Systems Center (ASC)	Wright-Patterson Air Force Base, Ohio
Army Corps of Engineers Waterways Experiment Station (CEWES)	Vicksburg, Mississippi
Army Research Laboratory (ARL)	Aberdeen Proving Ground, Maryland
Naval Oceanographic Office (NAVO)	Stennis Space Center, Mississippi

Table 4 — MSRC Focused Support of CTAs

Computational Technology Area	Major Shared Resource Center			
	CEWES	NAVO	ARL	ASC
Computational Structural Mechanics	X		X	X
Computational Fluid Dynamics	X	X	X	X
Computational Chemistry and Materials Science			X	X
Computational Electromagnetics and Acoustics		X		X
Climate/Weather/Ocean Modeling and Simulation	X	X		
Signal/Image Processing		X	X	
Forces Modeling and Simulation/C4I	X		X	
Environmental Quality Modeling and Simulation	X	X		
Computational Electronics and Nanoelectronics				X
Integrated Modeling and Test Environments			X	

Distributed Centers (DCs)

DCs provide HPC capability to a specified local and remote portion of the HPCMP user community. Modest-sized systems are deployed to DCs where there is a significant advantage to having a local HPC system and where there is a unique potential for advancing DoD applications. DCs leverage HPC expertise or address problems that cannot be readily solved at the MSRCs, such as real-time, near-real-time, embedded system applications, and man-in-the-loop and hardware-in-the-loop testing and evaluation. The centers are linked by high-speed communications to the MSRCs and remote users. Thus, they augment the MSRCs to form the total DoD HPCMP computational capability. Because DCs are typically established to exploit a unique opportunity, a sunset policy has been established to "retire" the center after completion of the anticipated work.

Networking

The Defense Research and Engineering Network (DREN) is a robust, high-speed network that provides connectivity among the program's geographically dispersed user sites and shared resource centers. Approximately 1,000 of the 4,000 HPC users reside at the MSRC sites, while the remaining 75% are at remote locations. The program's networking initiative is supported by the Defense Information Systems Agency and the Defense Advanced Research Projects Agency. DREN provides gateways to many existing military and civilian networks, allowing access to the program's resource centers from contractor and university facilities.

The networking services of DREN are provided by means of a virtual wide-area network built on a public communications grid supplied by American Telephone and Telegraph (AT&T) as part of the DREN Intersite Services Contract (Figure 4). Networking capability is specified as a given level of service at each site, with no definition of interconnecting pathways. Service levels at each site can be adjusted as requirements change. Adding and deleting sites from the network and increasing service levels can be easily accomplished. Because DREN uses commercial services, the DREN Intersite Services Contract can access the fastest available networking technology immediately upon entry to the commercial sector. Growing problem sizes, remote interactive visualization of computations, distance learning, virtual workshops, remote training, interactive collaborations, and heterogeneous computing across sites all place increasingly heavy demands on network bandwidth.

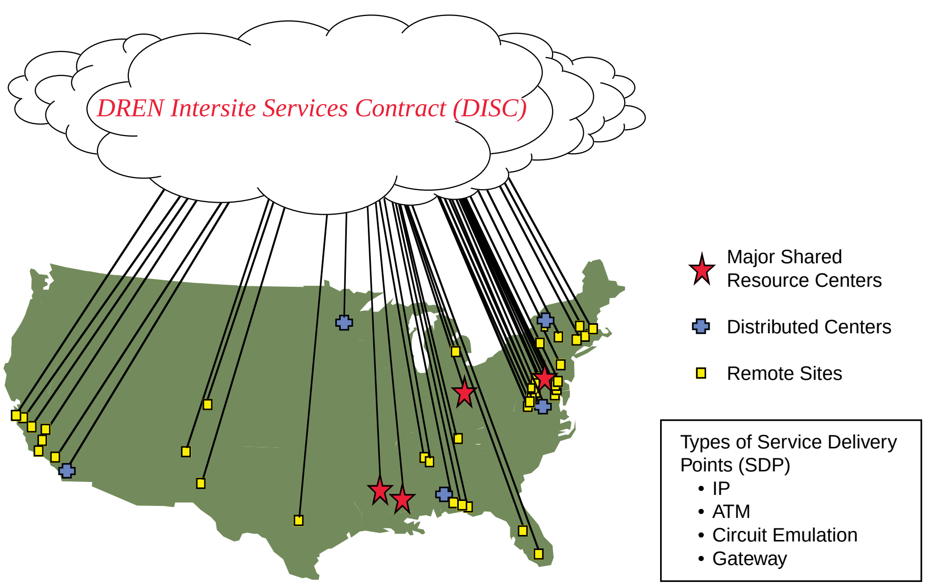


Figure 4 – DREN Intersite Services Contract

Common HPC Software Support Initiative (CHSSI)

CHSSI is building efficient, scalable, portable software codes, algorithms, tools, models, and simulations that run on a variety of HPC platforms and affect a wide number of S&T and DT&E scientists and engineers. CHSSI is organized around the 10 CTAs and involves several hundred scientists and engineers working in close collaboration across government, industry, and academia. CHSSI teams include algorithm developers, applications specialists, computational scientists, computer scientists and engineers, and end users.

CHSSI is helping prepare the DoD to take advantage of future computing and communications capabilities by building software with an emphasis on reusability, scalability, portability, and maintainability. In addition, CHSSI is producing a new generation of world-class scientists and engineers trained in scalable software techniques that will reduce the future costs of doing business and increase our future defense capabilities. Table 5 lists the current 43 CHSSI projects and principal investigators across the CTAs.

Table 5 — Common HPC Software Support Initiative Projects and Principal Investigators

Computational Technology Area	Project	Principal Investigator	Location
Computational Structural Mechanics	Small Deformation Structural Mechanics Large Deformation Structural Dynamics Scalable Algorithms for Shock Physics Structure-Medium Interaction Model	Gordon Everstine Raju Namburu Kent Kimsey Mark Emery	Naval Surface Warfare Center Army Waterways Experiment Station Army Research Laboratory Naval Research Laboratory
Computational Fluid Dynamics	FAST3D – Global Virtual-Cell Embedding Gridding COBALT – Unstructured Gridding FEFLO – Unstructured Gridding OVERSET – Chimera Gridding Zonal Navier Stokes – Block Structured Gridding Scalable NPARC	Jay Boris Bill Strang Bill Sandberg Bob Meakin Walter Sturek Jere Matty	Naval Research Laboratory Air Force Research Laboratory (Wright) Naval Research Laboratory Army – NASA Army Research Laboratory Arnold Engineering Development Center
Computational Chemistry and Materials Science	Car-Parinello Methods for Solids Quantum Chemistry Tight-Binding Molecular Dynamics Classical Molecular Dynamics	D.J. Singh Jerry Boatz D.A. Papaconstantopoulos Ruth Pachter	Air Force Research Laboratory (Wright) Air Force Research Laboratory (Edwards) Naval Research Laboratory Air Force Research Laboratory (Wright)
Computational Electromagnetics and Acoustics	Automatic Target Recognition and Scene Generation Electromagnetic Interaction Code Spectral Domain Low Observable Component Design Synthetic Sensor Phenomenology for Fusion Time Domain Numeric Methods for HPC Platforms High Resolution Computational Electromagnetics and Acoustics Code Magnetohydrodynamic Code	Jeff Hughes Jay Rockway Kueichien Hill Tom Blalock Helen Wang Miguel Visbal Robert Peterkin	Air Force Research Laboratory (Wright) Naval SPAWARSYSCEN, San Diego Air Force Research Laboratory (Wright) MSIC/Defense Intelligence Agency Naval Air Weapons Center (China Lake) Air Force Research Laboratory (Wright) Air Force Research Laboratory (Phillips)
Climate/Weather/ Ocean Modeling and Simulation	Ocean Models with Domain Decomposition Scalable Global Weather Forecast System Global and Regional Wind Wave Modeling	Steve Piacsek Tom Rosmond Robert Jensen	Naval Research Laboratory Naval Research Laboratory Army Waterways Experiment Station
Signal/Image Processing	Radar Signal Processing Scalable Algorithms for Sonar Beamforming Synthetic Aperture Radar/Image Formation HPC Embedded Applications for Target Recognition Infrared/Optical Image Processing for Reconnaissance and Surveillance	Rich Linderman Bob Bernecky Chris Yerkes Cathy Deardorf Lynda Graceffo	Air Force Research Laboratory (Rome) Naval Undersea Weapons Center Naval SPAWARSYSCEN, San Diego Air Force Research Laboratory (Wright) Army Night Vision Laboratory
Forces Modeling and Simulation/C4I	Scalable HPC Environment for C4I (SHEC) Simulation Leveraged Acquisition Test & Evaluation Efficient Parallel Discrete Event Simulation for Analysis HPC Frameworks for Warming and Training Simulations	Guy Leonard Henry Ng Bill Smith Larry Peterson	Naval SPAWARSYSCEN, San Diego Naval Research Laboratory Naval Research Laboratory Naval SPAWARSYSCEN, San Diego
Environmental Quality Modeling and Simulation	Structured-Unstructured Modeling Resolved Transport Algorithm Scalable Parallel Implementation of DoD Groundwater Modeling System	Robert Bernard Mark Dortch Fred Tracy	Army Waterways Experiment Station Army Waterways Experiment Station Army Waterways Experiment Station
Computational Electronics and Nanoelectronics	Scale Algorithms for Dynamic Nonlinear Simulations Power Electronics Simulation Parallel Very High Speed Integrated Circuit Hardware Description Language Simulation Electromagnetic Solvers for High Frequency Design	Dave Rhodes Robert Pastore John Hines Leo DiDominico	Army Comm and Electronics RDE Center Army Intelligent Electronic Warfare Center Air Force Research Laboratory (Wright) Army Research Laboratory
Integrated Modeling and Test Environments	Real Time Synthetic Test Environment Representation High Fidelity Physics Based Models for Testing Simulation Based Design and Test Technology	Harry Heckathorn Joel Mozer Andrew Mark	Naval Research Laboratory Air Force Research Laboratory (Phillips) Army Research Laboratory

PROGRAM ACCOMPLISHMENTS AND FUTURE PLANS

Major Shared Resource Centers

Concurrent acquisitions to establish the four MSRCs were completed in FY 1996, resulting in integration contracts to provide hardware, software, maintenance, operations, and support staffs. Each contract includes a base computational capability, Performance Level (PL) I, with two options for upgrade (PL II and PL III) as resources become available.

Table 6 shows the HPC systems installed and planned to be available to users effective June 1998. Since the first systems were fielded by the program in FY 1994, the total peak capability at the MSRCs has increased from 30 gigaflops to just over 1200 gigaflops at the end of FY 1997. Approximately 600 gigaflops have been added this year as part of the PL II upgrade. Further upgrades to the Army Research Laboratory MSRC are anticipated as the final increment of the PL II upgrade is completed. During this same period — FY 1994 to FY 1998 — utilization, both in terms of the number of users and the size and importance of the projects, has continued to rise sharply.

MSRCs FY1998

The program will sustain existing HPC capability at its four MSRCs and continue to modernize these sites by acquiring additional HPC systems, capacity, storage, and scientific visualization capabilities. Contract options will be exercised to upgrade capability, completing the second year of PL II. The program will also focus on developing a common "look and feel" for users across the centers. This includes login accounts, file structure, web design and user interfaces. Also, the Program Environment and

Table 6 — Major Shared Resource Center HPC Capability (as of June 1998)

Location	DoD HPCMP System	Number of Processors	Total Memory (gigabytes)	Total Capability (Peak gigaflops)
Army Corps of Engineers Waterways Experiment Station	Cray C90 IBM SP Cray T3E IBM SP P2SC SGI Origin 2000	16 256 336 126 128	8 256 86 63 64	16 138 302 81 51
Naval Oceanographic Office	Cray C90 SGI Origin 2000 Cray T90 SGI PowerChallenge Cray J932SE (Classified) SGI PowerChallenge (Classified) Cray T3E	16 128 24 52 12 8 544	8 64 8 16 4 4 139	16 51 43 19 2 3 490
Army Research Laboratory	SGI Origin 2000 Cray T90 SGI Origin 2000 (Secret) Cray T90 (Secret) Cray J932SE (Special Access) Cray J932SE (Special Access) SGI Origin 2000 (Special Access)	288 12 64 8 16 16 32	160 8 32 4 32 8 12	115 22 26 14 3 3 13
Aeronautical Systems Center	Cray C90 IBM SP SGI Origin 2000 SGI PowerChallenge	16 256 512 16	8 264 320 8	16 138 205 6

Training effort will continue to provide HPC training and technology transfer to the various DoD HPC users and will incorporate and integrate common programming tools and standards across the DoD HPC community.

MSRCs FY 1999

The program will sustain existing HPC capability and continue to modernize by acquiring additional HPC systems, capacity, storage, and scientific visualization capabilities. Over the two-year period — FY 1999 and FY 2000 — MSRC contract options will be exercised to upgrade performance at these centers, minimally resulting in a ten-fold increase over capability at each site in FY 1996. Improved operating environments and supporting tools and software will be firmly in place and tested across the CTAs. Additional training and interactions with outside government agencies, industry, and academic HPC centers will continue as the nation's HPC expertise, capabilities, standards, and infrastructure mature.

Distributed Centers

Augmenting the shared computational capabilities at the four MSRCs, the HPCMP established or upgraded DCs over the three-year period FY 1996 through FY 1998 (Table 7). In FY 1997, five existing centers were upgraded and one new center was created at the Redstone Technical Test Center. In addition to the DCs listed in the table, the Arctic Region Supercomputing Center, in Fairbanks, Alaska, was funded by Congress in FY 1996 through 1998 and is providing computational HPC resources to the user community.

DCs FY 1998

The program approved the acquisition of new systems or upgrades at five DCs as part of its FY 1998 implementation plan. Table 8 shows the HPC configurations at the DCs funded by the HPCMP as of March 1998. Additionally, distributed center proposals from DoD Services and Agencies have been solicited and will be evaluated late this year for FY 1999 award and implementation.

DCs FY 1999

The HPCMP will announce selection of the FY 1999 DC projects and will authorize acquisitions of the new or upgraded capabilities at the selected centers. The program will also solicit DC proposals for FY 2000 award and implementation.

Table 7 — Distributed Centers and Capability

Center	Location	Most Recent Upgrade (FY)
Air Force Arnold Engineering Development Center (AEDC)	Arnold Air Force Base, Tennessee	1997
Air Force Development Test Center (AFDTC)	Eglin Air Force Base, Florida	1996
Air Force Maui High Performance Computing Center (MHPCC)	Kihei, Hawaii	1998
Air Force Research Laboratory (Rome)	Griffiss Technology Park, Rome, New York	1998
Army High Performance Computing Research Center (AHPCRC)	Univ. of Minnesota, Minneapolis, Minnesota	1996
Army Redstone Technical Test Center (RTTC)	Redstone Arsenal, Huntsville, Alabama	1997
Army Space and Missile Defense Command (SMDC)	Huntsville, Alabama	1996
Army Tank-Automotive RD&E Center (TARDEC)	Warren, Michigan	1996
Army White Sands Missile Range (WSMR)	White Sands Missile Range, New Mexico	1997
Naval Air Warfare Center (NAWC)	Patuxent River Naval Air Station, Maryland	1997
Naval Research Laboratory (NRL)	Washington, District of Columbia	1998
Naval Undersea Warfare Center (NUWC)	Newport, Rhode Island	1996
Naval SPAWAR Systems Center, San Diego	San Diego, California	1998

Table 8 — Distributed Center HPCMP Resources (as of March 1998)

Location	DoD HPCMP System	Processors	Total Memory (gigabytes)	Total Capability (Peak gigaflops)
Air Force Arnold Engineering Development Center (AEDC)	Convex C4640 Convex C4640 (Classified) Convex Exemplar SPP-2000 HP Exemplar X (Classified) SGI Origin 2000	4 4 64 48 64	4 4 16 11 32	3 3 46 34 26
Air Force Development Test Center (AFDTC)	Cray T3D SGI Onyx	128 32	8 8	19 12
Air Force Maui High Performance Center (MHPCC)	IBM SP (Classified) IBM SP IBM P2SC IBM SMP IMB P2SC	96 192 51 64 192	13 31 7 8 96	26 51 25 14 123
Air Force Research Laboratory (Rome)*	Intel Paragon	321	21	30
Army High Performance Computing Research Center (AHPCRC)	Cray T3E	272	139	326
Army Redstone Technical Test Center (RTTC)	SGI Origin 2000 SGI Origin 2000 (Classified)	32 32	7 7	13 13
Army Space and Missile Defense Command (SMDC)	SGI Origin 2000 SGI Origin 2000 SGI Origin 2000 SGI Origin 2000 SGI Origin 2000	64 32 32 32 128	16 10 10 10 32	26 13 13 13 52
Army Tank-Automotive RD&E Center (TARDEC)	SGI PowerChallenge	64	16	24
Army White Sands Missile Range (WSMR)*	TMC CM-500 SGI Origin 2000	128 64	16 24	20 26
Naval Air Warfare Center (NAWC)	SGI PCA (Classified) SGI Onyx2 (Classified) SGI Onyx2 (Classified)	40 32 32	12 16 8	15 13 13
Naval Research Laboratory (NRL)*	TMC CM-500e TMC CM-500e Convex Exemplar SPP-2000 SGI Origin 2000	256 32 64 128	33 4 16 32	41 5 46 52
Naval Undersea Warfare Center (NUWC)	Cray T3D	64	4	10
Naval SPAWAR System Center, San Diego (SSCSD)*	Intel Paragon (Classified) Convex Exemplar SPP-1000	336 32	14 8	25 6

*Distributed centers funded for FY 1998 additional capability are not yet reflected in the table due to pending acquisition.

Networking

The Defense Research and Engineering Network (DREN) Intersite Service Contract (DISC) was awarded to AT&T in July 1996. The contract allows the government to purchase high-speed network service to anywhere in the United States at bandwidths ranging from 1.5 megabits per second to 155 megabits per second (OC3), with upgrade potential to 2.4 gigabits per second (OC48) over the five-year life of the contract. Thirteen Interim DREN sites were transitioned to DISC in Fiscal Year 1997.

Networking FY 1998

The Interim DREN network, established when the program began by consolidating pre-existing Air Force, Army, and Navy networks, will be phased out entirely as all network services are shifted over to the DISC. An additional 47 government sites will be implemented in FY 1998, bringing the total to 60. Options to increase bandwidth at selected sites will also be executed. Wide-area classified networking will enable support to classified processing requirements over DREN using high-speed Fastlane encryption technology.

Networking FY 1999

Network connectivity will be sustained for HPCMP users. Options to increase bandwidth at selected sites will be executed to meet increased demands resulting from upgraded computing capabilities at the various HPC centers. Additional sites will also be added to the DREN. Planning will begin to develop a follow-on DREN contract or transition follow-on high-speed support to standard Defense Information Systems Agency (DISA) network operations.

Common HPC Software Support Initiative (CHSSI)

The CHSSI Test and Evaluation Master Plan (TEMP) was approved in FY 1997, and 43 software projects were initiated to develop advanced scalable software codes, algorithms, tools, models, and simulations. Several CHSSI teams released alpha and beta software products in FY 1997, and preliminary evaluations of these products show a significant improvement in capability to efficiently exploit HPC scalable systems in support of a large number of DoD user projects.

CHSSI FY 1998

CHSSI will continue to develop reusable, scalable, and portable applications software to exploit massively parallel HPC systems. The focus of the year will be on software testing, and additional CHSSI projects will release alpha and beta software throughout the year. Each CHSSI project will be reviewed to assess the application of HPC technology to solve the defense problems being addressed. Projects no longer deemed appropriate or high priority, due to changing technology and/or requirements, will be discontinued. As projects succeed to full software release or are discontinued due to lack of progress or applicability, other areas of opportunity will be sought and new projects will begin.

Cross-collaboration with related technology efforts throughout the DoD and other federal agencies, industry, and academia will continue to strengthen. Emphasis will be on developing standard computing interfaces, user environments, visualization tools, and other capabilities that assist nontechnical users working on critical defense and national security problems to more easily exploit HPC capabilities.

CHSSI FY 1999

CHSSI software will continue to be developed, tested, and released to produce improvements in defense operations. Advances in high-speed computing and communications technology, especially in distributed computing, metacomputing, massively parallel HPC architectures, and remote desktop collaboration, will continue to change the way the DoD performs its warfighting and warfighting support missions. These changes will, in turn, produce new areas of opportunity.

Emphasis on strong software engineering, reusability, and maintainability will be expanded. Software and programming tools such as advanced compilers, debuggers, and system evaluation tools from inter-Agency efforts will be transferred and inserted into the DoD HPC community. These tools will greatly improve the accessibility and usability of HPC resources to a broader user base.

PROGRAM OFFICE ACCOMPLISHMENTS AND FUTURE PLANS

DoD Challenge Projects

To ensure that important computationally intensive problems receive priority resources, a set of DoD Challenge Project proposals are requested, reviewed, and awarded each year. These are then allocated approximately 20% of the program's total HPC capability. Projects are chosen annually, and recommendations are made by a selection board that includes reviewers from outside the DoD. Selection is based on priority military needs, scientific merit, and potential for progress. The FY 1998 DoD Challenge Projects are summarized in Table 9.

Table 9 — Fiscal Year 1998 DoD Challenge Projects

Primary CTA	Project	Organization	HPC System(s)
CSM	Development of Standards for Stand-Off Distance and Blast Walls for Force Protection	Army Waterways Experiment Station	IBM SP Cray T3E
CSM	Mine Plow Simulation by Smoothed Discrete Element Modeling	Army Waterways Experiment Station	Cray T3E IBM SP
CSM	Multistory Building Structural Response from Water Tamped Explosions	Army Waterways Experiment Station	IBM SP Cray T90 Cray T3E
CSM	Modeling of Complex Projectile-Target Interactions	Army Research Laboratory	Cray T90 Cray J90 Cray Origin 2000
CFD	Analysis of Jet Interaction Phenomena for the THAAD Interceptor	Army Space Missile Defense Command	Cray T90 Cray Origin 2000
CFD	Applied CFD in Support of Aircraft-Store Compatibility and Weapons Integration	Air Force Development Test Center	Cray Origin 2000 Cray T3E
CFD	Automatic Aerodynamic Design for Complete Aircraft Configurations Using an Adjoint Based Multiblock Method	Air Force Office of Scientific Research	Cray Origin 2000 Cray T3E
CFD	Parallel Simulations of Flow-Structure Interactions	Office of Naval Research	IBM SP Cray T3E
CFD	Parallel Simulations of Reacting Turbulent Two-Phase Flows	Army Research Office	Cray Origin 2000 Cray T3E
CFD	Simulation of Explosions for Counter-Proliferation and Counter-Terrorism Scenarios	Defense Special Weapons Agency	Cray Origin 2000 Cray T3E
CFD	Time-Domain Computational Ship Hydrodynamics	Office of Naval Research	TMC CM-5 Cray T90 IBM SP Cray Origin 2000 Cray T3E
CFD	Unsteady Hydrodynamics of the Maneuvering Submarine	Office of Naval Research	Origin 2000 Cray T3E
CCM	Dynamical Response of Low Dimensional Materials	Naval Research Laboratory	TMC CM-5
CCM	New Materials Design	Air Force Phillips Laboratory Air Force Office of Scientific Research	Cray T90 Cray Origin 2000 IBM SP
CCM	Theoretical Investigation of Gun Tube Erosion Related Requirement	Army Research Laboratory	SGI PCA Cray Origin 2000 Cray T3E
CEA	Airborne Laser Laboratory Challenge Project	Air Force Research Laboratory	Cray T3E IBM SP
CEA	B-1B Radar Cross-Section Prediction	Air Force Research Laboratory	IBM SP Cray Origin 2000
CEA	Computational Assisted Development of High Temperature Structural Materials	Air Force Research Laboratory Air Force Office of Scientific Research	IBM SP Cray Origin 2000 Cray T3E
CEA	Virtual Prototyping of RF Weapons	Air Force Research Laboratory	Cray T90 IBM SP
CWO	Global and Basin-Scale Ocean Modeling and Prediction	Naval Research Laboratory	Cray T3E
EQM	Quantification of the Impacts of Subsurface Heterogeneity on Military Site Cleanup	Army Waterways Experiment Station	IBM SP TMC CM-5 Cray T3E
CEN	Atomistic Simulation of MEMS Devices via the Coupling of Length Scales	Naval Research Laboratory	IBM SP
CEN	Quantum Simulation	Defense Advanced Research Projects Agency	Cray T3E

Challenge Projects produce, in a timely fashion, significantly improved models and simulations to address important defense problems. Such problems include determination of blast damage on structures for counter proliferation and counter-terrorism scenarios, disposal of expired munitions, mine warfare in littoral waters, and finer calculations of stealth signatures to improve invisibility across the electromagnetic spectrum. Summaries of several FY 1997 DoD Challenge Projects are included in the 1998 edition of *High Performance Computing Contributions to DoD Mission Success*.

Customer Requirements and Resource Allocation — Processes for gathering user requirements, upon which the program is based, were expanded in FY 1997 to include on-line input via the World Wide Web. Further, the HPC Modernization Office established a resource allocation policy to more effectively distribute the program's HPC resources and ensure timely results for DoD's highest priority computational projects. This new policy is being implemented at the MSRCs in FY 1998 and includes two parts: allocation of a specified portion of the program's total computing resources (20%) to support DoD Challenge Projects and allocation of the remaining compute cycles (80%) to support Service/Agency requirements. Of these remaining cycles, 30% are allocated to each of the Air Force, Army, and Navy, with 10% for Defense Agencies. Each Service/Agency then distributes its allocation according to its internal needs.

Security — Although the HPCMP retains overall security policy and oversight responsibilities, authority for security certification and accreditation of individual systems has been delegated to the host Services. In response to growing threats posed by the proliferation of computer system intrusion software widely available commercially and over the Internet, the HPCMP Security Working Group (SWG) met during FY 1997 to develop ways to strengthen existing safeguards to prevent unauthorized access to DoD HPC resources. Over the next year, SecureID™ cards that provide one-time passwords will be distributed to the entire DoD HPC user base and Kerberos™ authentication protocols will be implemented to enhance our security posture.

User Group Meetings — Annual user group meetings provide an important forum for interaction between users, program office personnel, shared resource center managers, and others involved in the program. The June 1997 meeting had the largest attendance to date, with more than 300 participants. This event was sponsored by the Naval Oceanographic Office MSRC and hosted by the San Diego Supercomputer Center in San Diego, California. The 1998 meeting will be hosted by the Army Waterways Experiment Station MSRC and Rice University in Houston, Texas. Beginning in 1998, the Shared Resource Center Advisory Panel — the program's user group leadership — has been designated as the "sponsor" of the annual user group meeting.

PROGRAM OVERSIGHT AND REVIEW

In FY 1995, the General Services Administration (GSA) issued a $1.1 billion Delegation of Procurement Authority (DPA) for the four MSRC contract awards. In FY 1996, GSA granted a $430 million DPA for the DREN Intersite Services Contract. The HPCMP is designated as a major automated information system program. As such, the Major Automated Information Systems Review Council (MAISRC) provides oversight to ensure that the program meets its required life-cycle management milestones. In April 1994, the Program Office received Milestone 0 approval to initiate the HPCMP, and Milestone I was granted in February 1995. The MAISRC conducted a formal Milestone II review in December 1995 and issued a favorable System Decision Memorandum to continue with acquisition and modernization on 4 January 1996.

The Milestone 2 decision was key to the substantial progress the program has made in the past several years. Milestone 2 approval granted the program authority to effect full and open centralized acquisitions for high performance computing system upgrades to the four MSRCs and contracted for the program's wide area network services with the DREN Intersite Services Contract. The approval further authorized high performance computing system upgrades at six DCs and the start of CHSSI projects. Subsequent MAISRC approvals in February and October 1997 have allowed the program to continue those software support projects and to provide upgrades for additional DCs.

The HPCMP has matured sufficiently so that 1998 will mark the first extensive testing cycle for the program. The Joint Interoperability Test Command (JITC), the DoD independent tester, is testing various facets of the program: two MSRCs, two DCs, and several software support projects. Preliminary evaluation of test results shows that the program is on track — moving ever closer to meeting the needs of our scientists and engineers.

BUDGET

Overall Program Budget

The DoD HPCMP is projected to spend $1,237 million for fiscal years 1998 through 2003. Table 10 shows the funding profile by year and major spending category for fiscal years 1996 through 2003, including actual budgets

Table 10 — Funding Profile ($M)

	FY 96	FY 97	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03
System Acquisitions	128.6	122.7	89.7	82.4	65.0	42.1	52.9	51.9
Networking	17.8	16.0	23.7	28.7	29.9	33.4	33.4	33.4
System Application Support	9.6	21.0	21.2	22.8	22.8	22.8	20.8	20.8
Sustainment and Operations	56.4	82.1	98.2	89.5	86.8	90.0	85.3	89.9
Total	212.3	241.7	232.8	223.3	204.5	188.3	192.4	196.0

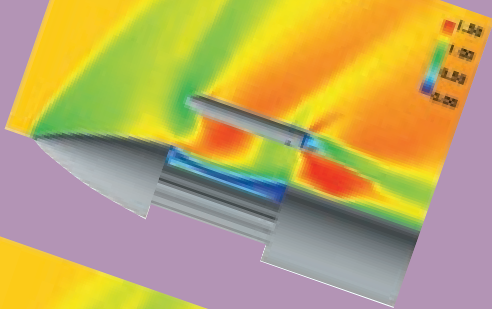
for fiscal years 1996 through 1998 and five-year projections from the President's FY 1999 budget. This funding profile represents a reduction of about $590 million from the initial budget profile shown in the FY 1994 modernization plan, and a reduction of $88 million from the profile presented in the FY 1997 plan. All of these reductions have been directed as a result of fiscal constraints within the Department of Defense. Although there have been a number of budget adjustments since the 1994 budget profile was presented, most of the reductions for fiscal years 2000 through 2003 are the result of a single $269 million reduction sustained by the program as part of the final resolution of the Defense Program Objective Memorandum (POM) for fiscal years 1997 through 2001.

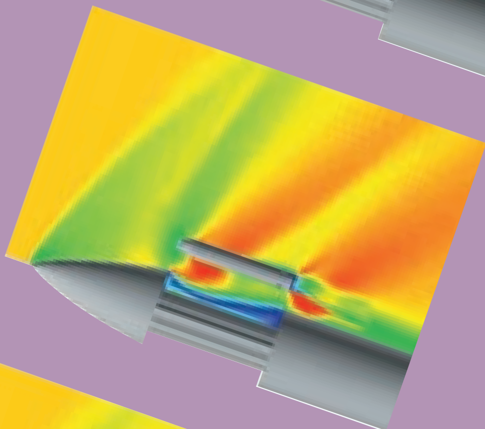
Comparison of the current budget profiles with earlier budget projections, industry briefings, and acquisition documents indicates that over 75% of the cumulative reductions referenced above — an average of almost $100 million per year beginning in fiscal year 2000 — will be sustained by the program's acquisition account as a direct result of the $269 million POM reduction. As stated in the FY 1997 modernization plan, the lower budget is sufficient to exercise the base capability as currently programmed for Performance Level III of the MSRC contracts. Given the rapidly increasing user utilization of the resource installed through Performance Level II, however, a majority of the projected user requirements will not be addressed by even this capability. Therefore, as part of its strategic planning efforts, the HPCMP staff continues to examine options to assure that the highest priority warfighter needs are met in light of these shortfalls. Other significant results of the out-year budget reductions include scaling back the growth rate for network capability and phasing out of most funding for DCs beyond fiscal year 2000. Both of these reductions will have the greatest impact on new or just emerging applications requiring either real-time or high-end interactive applications located remote to the MSRCs.

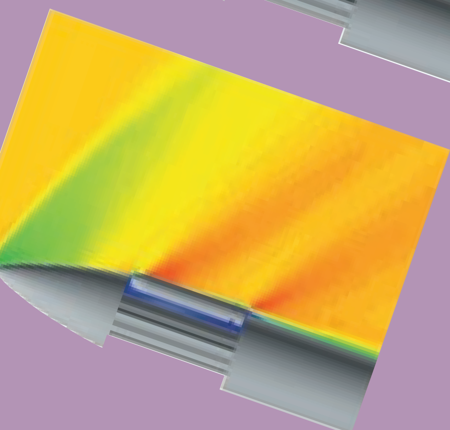
The continued strong funding in the software support initiative and the sustainment and operations budget lines reflects the importance that the program places on software, integration, and related shared services to the DoD's HPC user community. These investments will continue to guarantee that the focus of the program remains on enabling users to address warfighter needs, not only by strengthening the support infrastructure, but also by providing effective mechanisms for continued leverage of both national and industrial investments in HPC-based productivity.

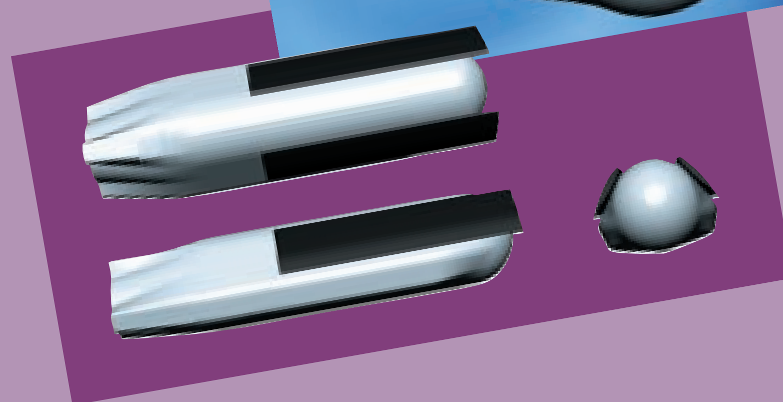
Produced for the DoD HPC Modernization Office
by the Publications Branch (202) 767-2782
Technical Information Division
NAVAL RESEARCH LABORATORY
4555 Overlook Avenue, S.W.
Washington, DC 20375-5333

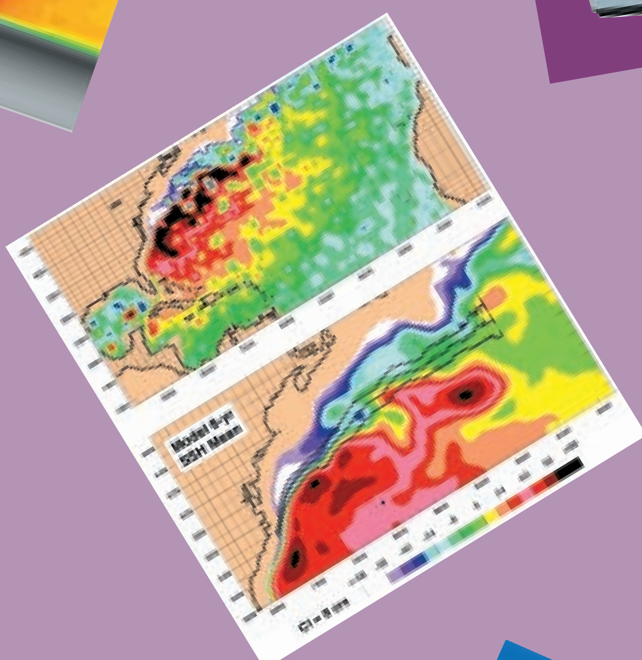
Editor: Marsha Bray and Maureen Long
Layout: Donna Gloystein
Cover design/graphic support: Jan Morrow and Suzanne Guilmineau

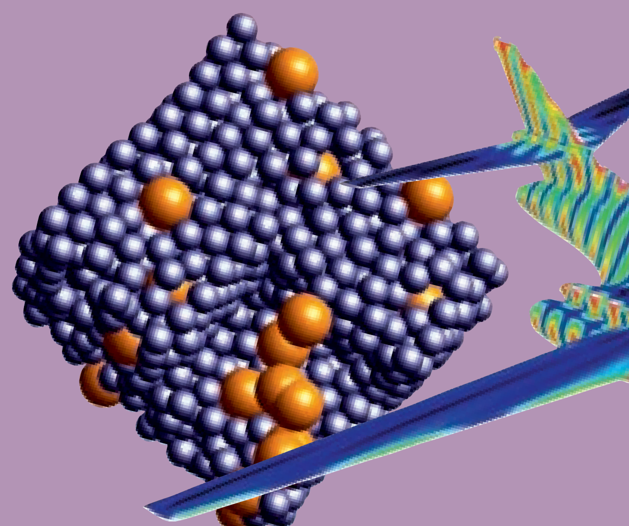












DoD HPC Modernization Office
1010 North Glebe Road, Suite 510
Arlington, VA 22210
Phone: (703) 812-8205
FAX: (703) 812-9701
http://www.hpcmo.hpc.mil